A DECISION SUPPORT SYSTEM FOR INVENTORY CONTROL

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CERTIFICATE

This is to certify that the present work on "A Decision Support System for Inventory Control", by C.N.Gupta has been carried out under our supervision and has not been submitted elsewhere for the award of a degree.

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C. N. Gupta

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CONTENTS

ABSTRACT

In this thesis, a Decision Support System has been developed to help the user in inventory decisions. The system blends the advantages of the analytical ability of Management Science/Operations Research techniques and the computational support of an interactive computer system. Various models, like static EOQ models, Discrete lot sizing models, Stochastic situations, Coordinated ordering of multiple items and Policy analysis for Selective control of items have been incorporated. Efforts have been taken to make the system sufficiently user-friendly . A modular approach has been followed in designing the system. This enables any future modificationsto the system quite easy. Throughout the design the stress has been on designing a support environment rather than in developing a simple computerized inventory system. The implementation has been done on the DEC-1090 computer system at IIT, Kanpur using PASCAL Language.

CHAPTER I

INTRODUCTION

1.1 COMPUTERS IN DECISION MAKING:

Over the last several decades there has been much speculation about the role of computers in management. Predictions that computers would take over many management functions encouraged counter claims that computers could have only minimal impact since most management functions cannot be automated. The experience to date has fallen between the two extremes. Although very few management functions have been automated, advances in information retrieval, processing, and display technologies have certainly led to significant computer applications, that help people perform management functions. Ever since, Management Information System replaced Electronic data process system as the popular term denoting computer applications in business, computer aided decision making in organizations has been the object of high hopes. Although the computer industry has enjoyed remarkable success in transforming the way business transactions and data are processed. MIS and management science professionals have been disappointed by the relatively limited use of these systems for managerial decision making. In these circumstances

Decision support systems emerged as new, practical approach for applying computers and information to the decision problems faced by management.

1.2 DECISION SUPPORT SYSTEMS:

Decision support systems (DSS) represent a point of view on the role of the computers in the management decision making process. Decision support implies the use of computers to: [15]

1. Assist managers in their decision processes in semi-structured and unstructured tasks.
2. Support, rather than replace, managerial judgement.
3. Improve the effectiveness of decision-making rather than its efficiency.

A task is said to be unstructured when, [4]

1. Objectives are ambiguous and non operational or objectives are relatively operational but numerous and conflicting.
2. It is difficult to determine the cause of changes in decision outcomes and to predict the effect on decision outcomes of the actions taken.
3. It is uncertain as to what actions taken by the decision maker might affect decisions.

The second term in phrase is support: a DSS supports and does not replace the manager. This emphasis on enhancement

of decision making exploits those aspects of computers and analytical techniques that are appropriate for the problem and leaves the remainder to the manager. Many problems have components that can be structured and others that require subjective assessments. In pricing some consumer products, for example, management intuition alone is inadequate, a computer model alone is also inadequate, but the two together may be most effective.

Compared with effectiveness, efficiency implies a narrowing of focus in order to get a specific job done. Typically, it takes the form of minimizing time, cost, or effort to complete a given activity. Effectiveness, on the other hand implies a broadening of focus in order to find out what set of activities should be considered. It requires defining and searching a decision space to become more confident that the goal itself is relevant and appropriate.

1.3 INVENTORY MANAGEMENT:

In the aggregate, inventories affect the economy through business cycles. Individually they provide the means by which we can effectively organize operations such as purchasing, manufacturing and distribution so that ultimately the end user receives any desired level of service. At the level of the firm, inventory is among the largest investment made and therefore logically deserves to be treated as a major

policy variable highly responsive to the plans and style of top management.

In general the larger the inventory the easier it is to plan operations and work force levels, the easier it is to reduce costs of purchasing, manufacturing and shipping, the easier it is to provide prompt customer service. At the same time, a larger inventory also requires a larger investment of money and has associated with higher costs such as storage, handling, risk of obsolescence and data processing. The management tries to balance these latter costs against the advantages achieved from stocking larger amounts in inventory.

1.4 DSS FOR INVENTORY MANAGEMENT:

As such solving an inventory model is a structured problem. But some features like policy analysis, analyzing alternate models, coordinating multiple items etc., make the inventory system design semi-structured. So the analytical power and computational ability of the computer can be rightly combined with the intervention of the management to formulate a decision support system.

1.5 OUTLINE OF THE THESIS:

This thesis presents the design and implementation of a decision support system for inventory policy decision making.

Selecting a policy for different kinds of inventory problems forms a good model for a semi-structured task. As explained earlier, inventory plays an important role in the organization. It needs considerable management attention. This task is performed by higher level managers who are not expected to know programming skills, they will not be able to do the task without the help of a fast tool like computer either. This system attempts to support the manager in deciding inventory policies wherever possible.

Another component of this thesis is user interface. The success of DSS depends to a large extent on a good human/ computer interface. It is all the more important for a DSS that the user and the system interact in a conversational mode to supplement the users judgement with the analytical power of the computer. Since most of the unstructured problem are facedby higher levels of management, who are usually non-computer professionals the interface should be comfortable for them, to use the system.

1.6 ORGANIZATION OF THE THESIS:

Chapter II outlines a quick summary of literature relevant to Decision Support Systems and Inventory System.

Chapter III presents the design of the system, various models used and the interface developed.

Chapter IV gives the details of implementation and the procedures used.

Finally, Chapter V outlines the conclusions drawn from the current exercise.

An example session with this system appears in appendix at the end.

CHAPTER II

DSS AND INVENTORY MANAGEMENT

The term Decision Support System refers to a class of systems which support the process of making decisions. Decision Support Systems allow the decision maker to retrieve data and best alternative solutions during the process of problem solving [6].

2.1 CHARACTERISTICS OF DSS:

The concept of DSS is based on several assumptions about the role of the computer in effective decision making [9].

1. The computer must support the manager but not replace his or her judgement. It should therefore neither try to provide the answers nor impose a predefined sequence of analysis.

2. The main pay-off of computer support is for semi-structured problems where parts of the analysis can be systematized for the computer, but when the decision makers insight and judgement are needed to control the process.

3. Effective problem solving is interactive and is enhanced by a dialog between the user and the system. The user explores the problem situation using the analytic and information providing capabilities of the system as well as human experience and insights.

2.2 SUPPORT FOR DECISION MAKING PHASES:

Decision making process consists of three phases: intelligence, design and choice [8].

The intelligence phase of the decision making process consists of problem finding activities related to searching the environment for conditions calling for decisions. Analysis and choice cannot proceed until the problem has been identified and formulated. The intelligence phase, therefore, consists of searching or scanning the internal or external environment for conditions which suggest an opportunity or a problem. Following the intelligence phase, the design phase involves inventing, developing and analyzing possible courses of action. The choice phase requires the application of a choice procedures and the implementation of the chosen alternative. A decision support system, by definition does not make a choice. However, optimization models, and suggestion models can be used to rank the alternatives and otherwise apply decision choice procedures to support the choice of the decision maker.

A successful decision maker goes through these phases carefully. The decisions are not any strange happenings, but they are taken by some one who knows about the problem better than others. As previously mentioned a decision maker's understanding is augmented by artificial means like providing various models and enlarging the domain in the decision space for better search of alternatives.

2.3 COMPONENTS OF A DSS:

To realize the potential decision support, a set of components must be put together. The first and most important element is the manager, who is intimately involved in the decision process. His skill and knowledge of the problem area cannot be substituted by any machinery or model, however intricate. The remaining four parts of the system are: models, a computer, a communication device to permit the manager and the computer to work together and a source of raw data upon which the manager and the computer can draw when necessary.

2.4 DSS FRAMEWORK:

The generic DSS framework [10] maintains that any decision support system can be viewed as having three systems. As shown in Fig. 2, these are its language system (LS), Knowledge System (KS) and Problem Processing System (PPS). A user states problems for a DSS to solve by using a language system. A decision support systems KS holds facts about an application area that are relevant to solving problem arising for that application. The problem process lies at the heart of a DSS, accepting problems represented with the LS and utilizing application. Specific knowledge represented in the KS in order to generate information for decision support.

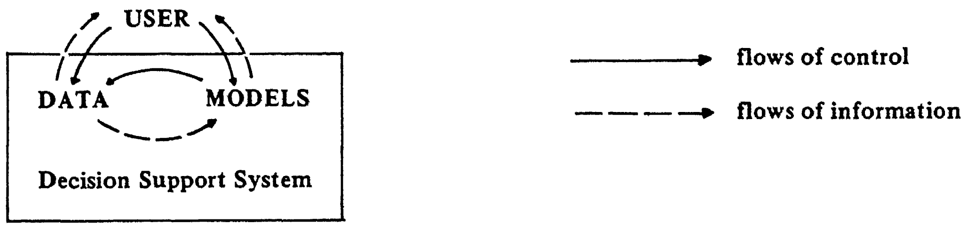

Figure 1

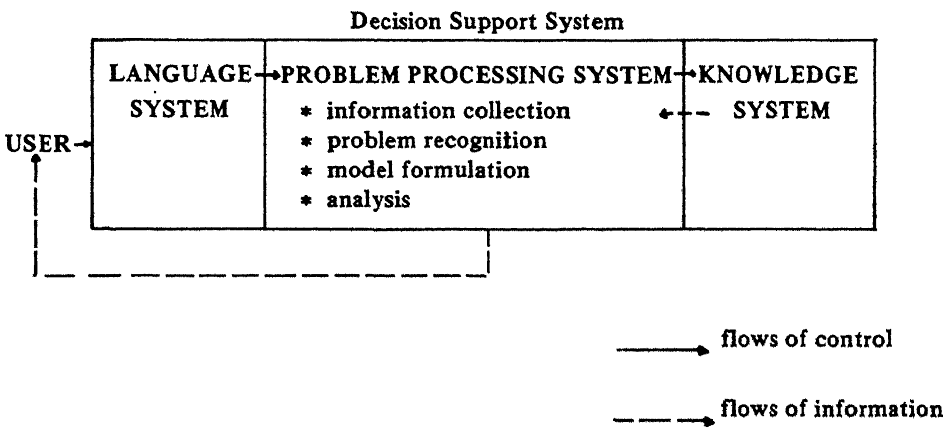

Figure 2

As a minimum any PPS must have the abilities to gather information from the user (expressed via the LS) and from a Knowledge System. The latter involves manipulation of data, in the KS, while the former ability involves the manipulation of LS expressions. A PPS must also posses the ability to explicitly recognize problems by transforming problem statements into appropriate executable plans of action. Where models are involved, another vital PPS ability is that of analysis. Analysis is the process of interfacing models with data in order to generate some beliefs, facts or expectations.

2.5 KEY FACTORS FOR SUCCESSFUL DSS:

There are several key factors to the successful development and implementation of decision support systems. Among those are [31]

a) Systems Development Process:

For effective systems development, the scope of the decision support system should be broad enough to make sure that the desired results are achieved in effective manner. This important factor has two aspects. First, they must be concerned about the procedures by which data will be gathered and entered into the system as well as procedures for getting to this group or data for supporting decision making. The second aspect is that every decision support system is itself

a subsystem of some larger system. Systems analysts must not try to construct a subsystem to meet certain objectives when they really need to be working with a broader system.

b) Management, User, and Systems Personnel Involvement:

Failure to include the user in the systems development process may result in less than desirable results. The characteristics of the user dictate the permissible forms that the decision support system can assume. Hence, although the DSS discipline has a rich set of mathematical and statistical tools, ignorance of what they can do and how they can be used leads to possible improper interpretation of system output, which, in turn can result in an unused decision support system.

c) Utilization of System Analysis as Change Agents:

System analysts can best achieve the goal by developing an awareness of change concepts and insightfully taking on the appropriate change role(s) as the situation demands.

2.6 A REVIEW OF DSS LITERATURE:

The earliest definition of DSS (e.g. Gorry and Scott Mortan [1971]) identify DSS as systems to support managerial decision makers in unstructured or semi-structured decision situations. A refinement of these early definitions is provided by John Little (1970) in his definition of a 'decision calculus'. He defines this as a model-base set of

procedures for processing data and judgements to assist a manager in his decision making. Three other definitions of DSS are offered by Moore and Chang [1880], Bonczek, Holsappe and Whinston [1980] and Keen [1980].

Simon s [30] distinction between programmable and non-programmable tasks is centred to the argument that Decision Support provides a strategy for making the computer useful to managers, whose decisions are relatively unstructured. Newell, Simon and Shaw's work on human problem solving has become the most well established 'behavioural' perspective in MIS and management science.

In the 1960's Prototype interactive systems were developed. In 1978 many of the interactive tools initiated projects by MAC were becoming common place. It is worth stressing, however that most of these techniques were developed well before 1970 and they were mainly the outcomes of academic and technical research projects. Between 1971 and 1976 a lot of work in DSS was done. Simultaneously the area of interactive computing also developed enough to be used together. Donovan [1976] describes the development and use of Generalized Management Information System (GMIS) to support ad hoc decision making. A survey by Naylor and Schauland [1976] documents a marked growth in the use of DSS generators for the projection of financial statements and the development of more general corporate planning models.

The concept of Model Management Systems (MMS) is an innovative product of DSS research, Elam et al [1980]. An example of an operating (MMS) is contained in Sprague and Watson [1976]. Two approaches involving the use of Artificial intelligence techniques are proposed by Elam et.al.[1980].

2.7 THE INVENTORY PROBLEM:

Inventory situations are fundamentally alike, each involving some aspects of cost, service, and usage. The objective in any given situation is to make that set of decisions which will minimize total costs and provide an acceptable or economical level of service at the expected demand or usage rate. The problem is solved on an item basis where it is required that the following information be determined for each item.

1. Appropriate costs
2. Expected service level - permissible incidence of stock shortages.
3. Forecast of usage
4. Replenishment characteristics e.g. lead time.

Each inventory problem will differ somewhat in the specific use of quantitative methods necessary for control and management. The level of sophistication required in employing decision models and the supporting facts and forecasts will depend on the unique characteristics of each situation.

Inventory models are usually classified according to whether the demand for a period is known (deterministic demand), demand varies period to period (Dynamic demand) or whether it is a random variable having a known probability distribution (Random demand). Another possible classification relates to how the inventory is reviewed, continuously or periodically.

2.7.1 The Role of Top Management:

The organizational role of top managers is aggregate business planning, strategy and control [13]. Senior management has the responsibility for defining in broad outline what needs to be done, and how and when it should be done. Top management also must act as the final arbiter of all conflicts between the operating divisions and has the ultimate responsibility for seeing that the general competitive environment is monitored and adapted to effectively. It is clear that, regardless of the organization, top management's feelings about financial constraints, performance levels and operating budgets will always have a bearing on the inventory management decisions.

2.8 REVIEW OF INVENTORY LITERATURE:

For over one half century the literature (encompassing literally hundreds of books and journals) has included frequent writings on the general field of inventory management.

The three key questions that inventory management attempts to answer on an item-by-item basis are:

i) How often should the inventory status be determined.

ii) When should a replenishment order be placed,

iii) How large should the replenishment order be.

Basically there are four categories of costs relevant to inventory decision making, namely, i) replenishment costs, ii) carrying costs, iii) costs of insufficient supply in the short run and, iv) system control costs as already mentioned.

There is enormous variety of inventory management problems (or models) of potential interest. These classifications are provided by Aggarwal [2], Eilon and Lampkin [9] and Nahmias [22].

In 1951, fixed order quantity [square root formula] with instantaneous replenishment and no shortages has been developed. Extensive effort has been devoted to the so-called dynamic lot size problem (Wagner and Whitin [32]) where the demand demand level changes from period to period but in a known fashion. In particular heuristic procedures (see Chapter 8 of [13]) have led to a more wide spread use of mathematical decision rules. Silver and Meal [27] have developed a simple variation of the basic EOQ. The effects of inflation in a stationary demand context have been treated by Buzz Cott [7], White Naddor [21] has dealt with the case of special opportunity to buy at a reduced unit cost.

Useful models have been developed (see Goyal [11] and Silver [28]) for determining replenishment sizes of a family of items that have inter-dependent costs of replenishment. Recent attention has been devoted by several authors to problems in which perishability of the product is crucial. In particular, Nahmias [22] has developed a reasonably simple, approximate procedure for deciding on the order-up-to level in a periodic review system. A number of authors (see for example, Schwarz and Scharge [25]) have developed decision rules for the special case of deterministic demand which should be useful in treating the more realistic case of probabilistic demand.

Many organizations are not taking advantage of available procedures for the subset of solved problems. Obviously there exists a substantial gap between theory and practice in inventory management. Herron [13], Krupp [16] and Silver [29] specifically discuss the use of programmable calculators in inventory management. Little [17] and Hurrion [14] present illustrations of the use of the computer in interactive decision making.

CHAPTER III

SYSTEM DESIGN

3.1 INTRODUCTION:

The success of DSS lies in its ability to model semi-structured and unstructured problems. This system is designed to support the manager in handling semi-structured inventory related decisions, wherever possible. The system interface is a mix of Question/Answer interface, Menu based interaction and form oriented input/output. This system can support in solving Deterministic models, Discrete lot-sizing models, Stochastic situations and in Coordinating multiple items as well as Policy analysis for selective control items. The interface between the user and the system tries to select the model, the manager would want to use. The system takes different paths depending upon the answers to the Query raised by the system. With the help of the answers to the previous questions it generates some more questions. The dialogue between the user and the system continues until the user is satisfied with the results.

3.2 SEVERAL VIEWS CONSIDERED:

The present system is designed on the basis of different views as explained below:

1. Computational Support:

If the over all problem solving process involves a large amount of computation and data manipulation then computational power is desirable. The situation might occur either with a large data base and relatively little manipulation, or with a smaller data base and very high amounts of computations. The former situation arises in deciding coordinated policies for a number of items, the latter arises in using Wagner-Whitin type algorithm.

2. Sensitivity:

The user can analyze the results with the changes in several parameters. He can experiment with his own policies and compare the results with the optimum ones.

3. User's Judgement:

The problem could be characterized as a situation calling for a considerable degree of judgement, to determine what constitutes the problem as well as to find answers to the problem. Both the problem-finding and problem-solution process require managerial judgement in complex situations. For example in coordinating multiple items (A, B and C items) the manager has to judge the outputs given by the system and try different combinations of coordination accordingly.

4. Integration:

Finally the system design stresses upon integration of all the various models and making use of the results of one model in another model. For example the user may like to see what happens if a stochastic situation is treated as deterministic one. If the results are very close then he may not risk replacing a deterministic situation with a stochastic one. As for another example, the user can visualize the effects of ordering the multiple items independently rather than coordinating them.

3.3 METHODS AND ALGORITHMS USED:

The system addresses state, dynamic and stochastic situations of a single item, coordination of multiple items with order cost interaction and resource constraints as well as suggesting policies for A, B and C items.

Following are the models incorporated in the system.

3.3.1 Simple EOQ:

With the assumptions that demand rate is constant and no shortages this model is incorporated in deciding the order quantity for a single item.

3.3.2 Extensions to EOQ:

The following extensions to EOQ model are implemented.

1. Finite Replenishment Rate:

One of the assumptions inherent in the derivation of the EOQ was that the whole replenishment quantity arrives at the same time. If instead, it is available at a rate of m per unit time the EOQ is formulated.

2. Shortages allowed:

It may be profitable to permit shortages to occur because the cycle length can be increased with a resultant saving in set-up costs. However, this benefit may be offset by the cost that is incurred when shortages occur. This option is allowed for user in this system. Two types of shortages costs viz., time dependent shortage costs and time independent shortage costs are taken care of.

3. Quantity discounts:

In simple EOQ model the assumption is made that the unit variable cost does not depend upon the replenishment quantity. In many practical situations discount on price are allowed based on the quantity ordered. This system provides scope for two types of discounts.

a) All unit quantity discounts:

The material cost is defined as follows:

$$C = \begin{cases} C_o & \text{for} \quad m_0 < Q \leq m_1 \\ C_1 & \text{for} \quad m_1 < Q < m_2 \\ \vdots & \\ C_j & \text{for} \quad m_j < Q \end{cases}$$

The discounted prices obey the relationship $C_o > C_1 > \ldots C_j$. The numbers $m_0, m_1, \ldots, m_j$ are assumed given and are called break points. The problem is to find Q , the minimum cost value of Q[18].

b) Incremental Quantity discounts:

The unit material cost in this case has this form [18]. For each order placed the cost per unit is

$$C = \begin{cases} C_0 & \text{for each of the first } m_1\text{-1 units} \\ C_1 & \text{for each of the next } m_2\text{-}m_1 \text{ units} \\ \vdots & \\ C_j & \text{for each unit in excess of } m_j \text{ -1 units} \end{cases}$$

As before $C_0 > C_1 > \ldots C_j$.

3.3.3 Discrete Lot Sizing:

1. Wagner-Whitin Algorithm:

We consider the planning horizon to be divided into N periods having known demands $D_1, D_2, \ldots, D_N$. A single lot may be procured in each period. Let Q_t denote the size of the lot procured in period t. There is a fixed cost of A_t if a lot is procured in period t and unit variable cost V_t which can vary from period to period. There is an inventory

cost of h_t to carry a unit in stock from period t to period t+1. The problem is to determine the lot sizes $Q_1, Q_2, \ldots, Q_N$ which minimize the sum of procurement costs and inventory costs over the N periods. This algorithm is adopted to find out the ordering quantities in each period [20].

2. Silver Meal Algorithm:

When ordering costs, holding costs and unit costs are constant this algorithm is adopted [23].

3.3.4 Stochastic Models:

This system takes care of (a) Single Period Model (News boy) and (b) Continuous Review Case.

a) News Boy Model: This model is concerned with the situation of deciding the quantity to be procured in independent period. In the case of demand during lead time Normal distribution is assumed. There is an underage cost C_u, associated with each demand which he cannot meet and an overage cost C_o associated with each demand that he is not able to sell.

b) Continuous Review Model: A fixed Quantity Q is ordered whenever the inventory position drops to the reorder point or lower. The inventory position and not the net stock is used to trigger an order. Both backorder case and lost sales cases are considered [20].

3.3.5 Coordinated Replenishment:

The previous models recognize only single stock items. Multiple-item ordering decision models are useful simply because they recognize interactions among the items involved. Item interactions as identified in this system are of two types: interactions resulting from resources and costs.

1) Ordering cost interaction:

In this model it is assumed that the cost of placing an order is K plus k_j if item j is ordered. There are n items altogether, so that if every item is ordered in a single order, the ordering cost is $K + k_1 + k_2 + \ldots + k_n$. An iterati procedure which gives optimum solutions in most of the cases and sub-optimal solutions in the remaining situations, is followed. The solution procedure can be outlined as follows:

Step 1: Determine the values of τ_j by using the following equation:

$$\tau_j = \sqrt{\frac{2\, k_j}{h_j\, d_j}}$$

Step 2: Determine α_j from the equation

$$\tau_j = \alpha_j \tau_1$$

and rank the items in their time between orders:

$$\tau_1 \leq \tau_2 \leq \ldots \tau_n$$

Step 3: Computer $[\alpha_j]$ by rounding off α_j.

Step 4: Calculate t_1 as follows:

$$t_1 = \sqrt{\frac{2(K + \sum_{j=1}^{n} \frac{k_j}{[\alpha_j]})}{\sum_{j=1}^{n} h_j \, d_j \, [\alpha_j]}}$$

Step 5: Again compute $[\alpha_j]$ by rounding off the value (τ_j/t_1) [if $\tau_j/t_1 < 1$ then $[\alpha_j] = 1.$].

Step 6: With the new $[\alpha_j]$ values compute t_1.

Step 7: Repeat the steps 5 to 6 till the values of $[\alpha_j]$ are same with the previous iteration.

2) Resource Interaction:

The second type of multi item model to be treated in this system is one which recognizes interaction among multiple items because the items share resources in common. The finite capacity of the resource acts as a constraint which restrict the actions of the ordering decision maker. The ordering policy is to order Q_j units of item j [18]. The items interact interact through a constraint of form

$$\sum_{j=1}^{n} \alpha_j \, Q_j \leq M$$

where,

α_j = Resource per unit of item j.

M = Resource (Ex. storage capacity, budget, etc.)

3.3.6 Policy Analysis:

Classification of items on the basis of Annual Usage value is done. Coordination of A, B and C items with respect to ordering cost is implemented.

3.4 FEATURES PROVIDED:

Considerable stress is given to the interface to guide the user to the particular type of inventory situation. The user is provided with the option of modifying some parameters and by the models again. The user can use his own policy and can compare the results with the optimum policy. He can try different alternatives and arrive at a feasible one.

In the case of stochastic situation the user can try this model as a deterministic model and compare both the results. Another feature provided is comparing the results when multiple items are ordered independently and jointly. In Dynamic demand situations the user can use his own monthly policy and see the cost figures.

In the next stage, the user can classify the items in A, B and C items by specifying the cut-off values. The provision is made to the user to change the classification. If there is any existing policy then the system provides the user with both the existing policy and optimum coordinated policy results. To enable him to compare those policies the system also provides the item cost details at each ordering point of each policy.

This provides an opportunity for the user to see whether there are any group Quantity discounts possible. In case, if the existing policy is uneconomical and optimum policy is inconvenient to follow the system guides the user to the policy which can be a trade-off between optimum policy and existing policy. The system provides the user the necessary information about costs, penalties if the ordering times are different from individual optimum, and savings in fixed ordering costs. This will greatly help the user in generating different alternatives. The system with its analytical capabilities can evaluate all the alternatives and support the decision maker in arriving at a a economical policy. Provision is also made to guide the user to an economical policy if he is not having any existing policy.

In designing the system more emphasis is put on designing the interface which is the key to the success of DSS. The user and system can interact in a conversational mode so that the user can supplement his judgement with the analytical power of a computer.

A modular approach is followed in designing this system. The code is designed in independent modules. This enables the possible changes in future and provides clear understanding. Even the dialogue between user and the system is local to the different procedures so that any modification can be independently undertaken.

CHAPTER IV

SYSTEM IMPLEMENTATION

4.1 INTRODUCTION

In this chapter we discuss the specific implementation details of the system including various subprograms and their structure and how they are linked together. The basic implementation strategy is as follows:

4.2 ELEMENTS OF SYSTEM CODE

The code for DSS consists of three parts as explained below:

1. The main program and most of the procedures are written in PASCAL, which supports various decision models and interacts with the user.

2. Some FORTRAN subroutines are called from the IMSL and NAG Libraries for use in the STOCHASTIC inventory models.

3. The linking between the PASCAL program and FORTRAN subroutines is done through the procedure called FTNLNK. This is the first procedure invoked in the PASCAL Program.

4.3 FLOW DIAGRAM

The implementation flow diagram of this system in terms of self explanatory procedure names is shown in Fig.4.1. This system consists of the following five subsystems:

1) Deterministic
2) Dynamic
3) Stochastic
4) Coordinated and
5) ABC Analysis,

which are briefly discussed below.

As soon as the system starts executing, the system attempts to find out which kind of inventory model the user wantsto use. This is done by a separate procedure, called FIND MODEL which basically interacts with the user through a set of questions. Accordingly the system passes control to the required subsystem.

4.3.1 Deterministic

This subsystem deals with the static demand situations With an another set of questions the system makes further search in finding out the exact model, the user would like to use. The other procedures in this subsystem are:

1) Get-Option:

With a set of questions this procedure finds out the deterministic model to be used.

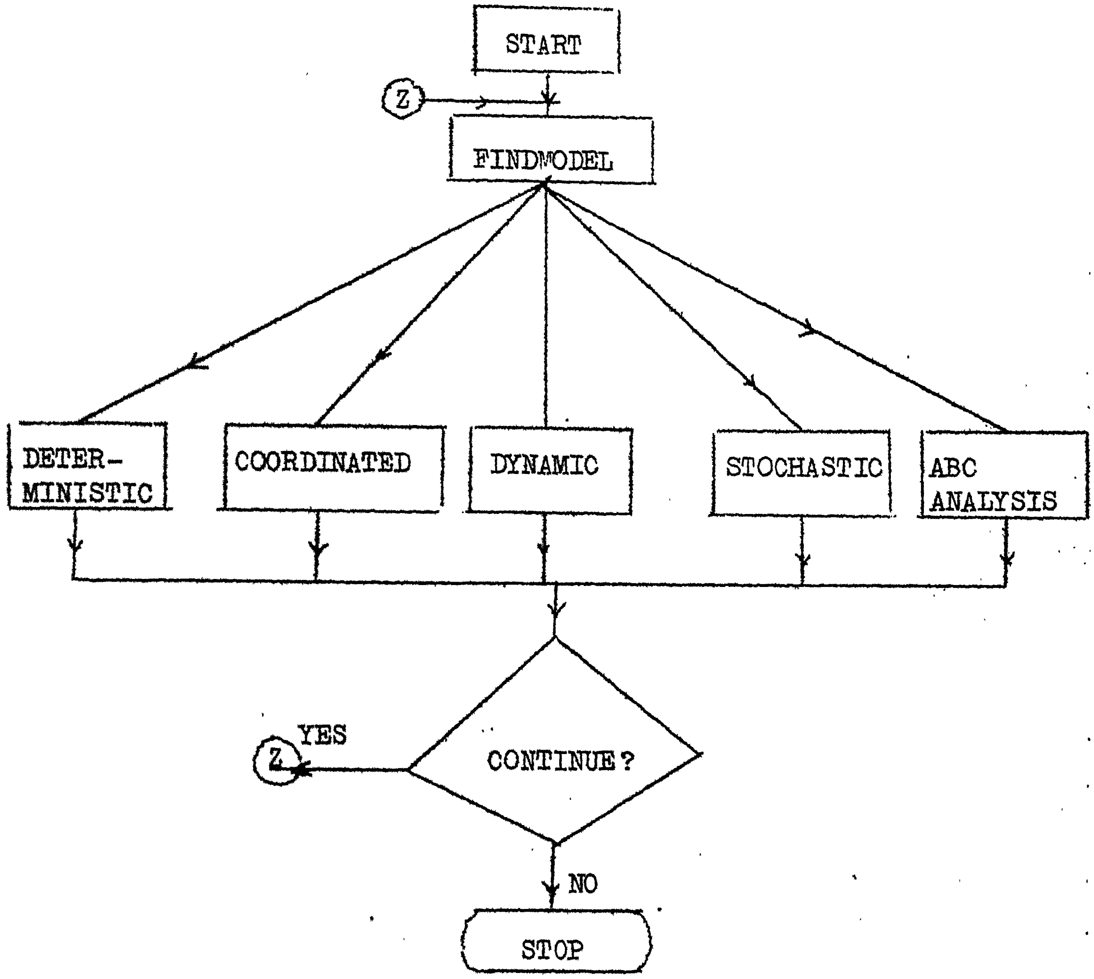

FIG. 4.1: MAIN SYSTEM.

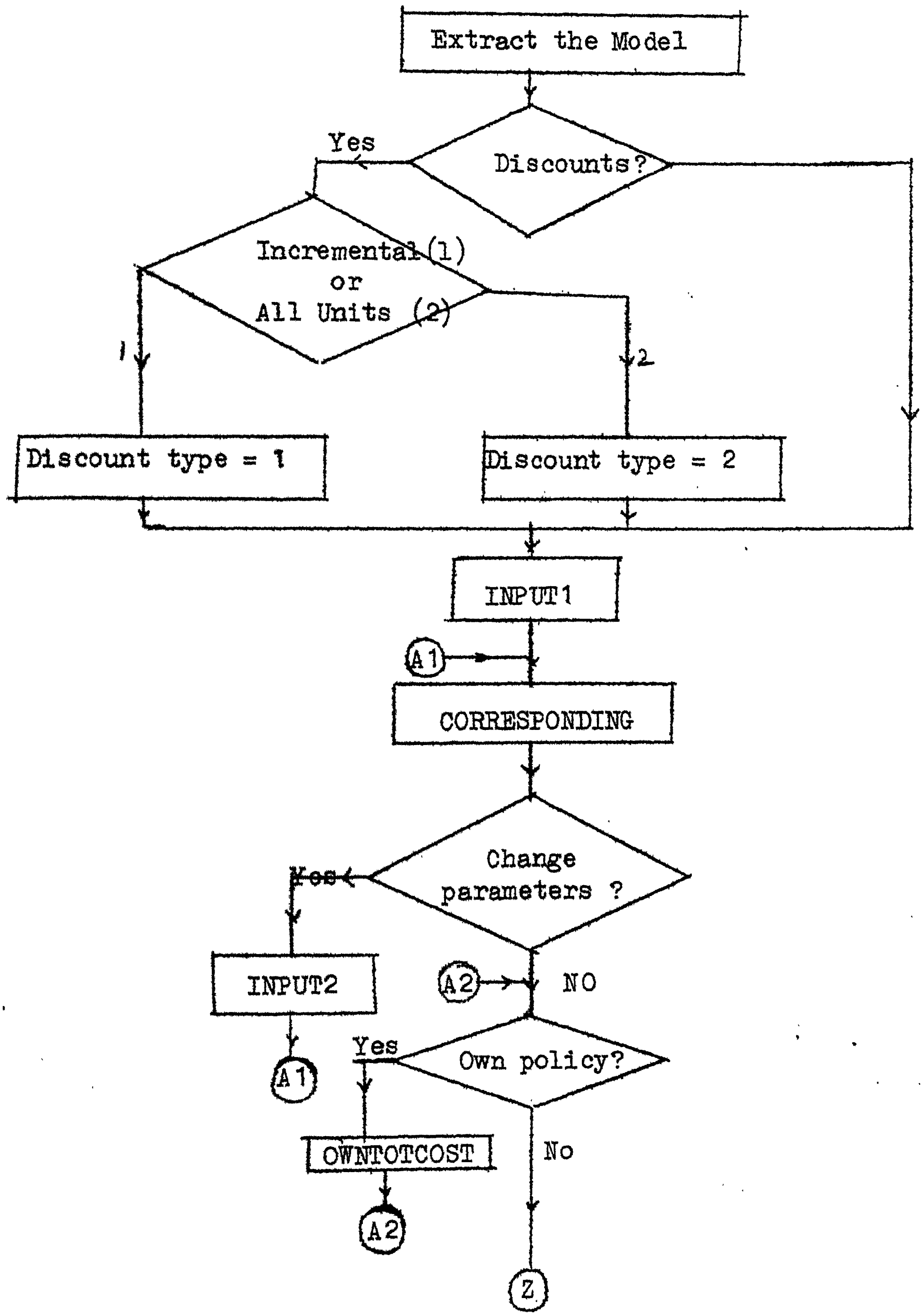

FIG. 4.2: DETERMINISTIC SUBSYSTEM.

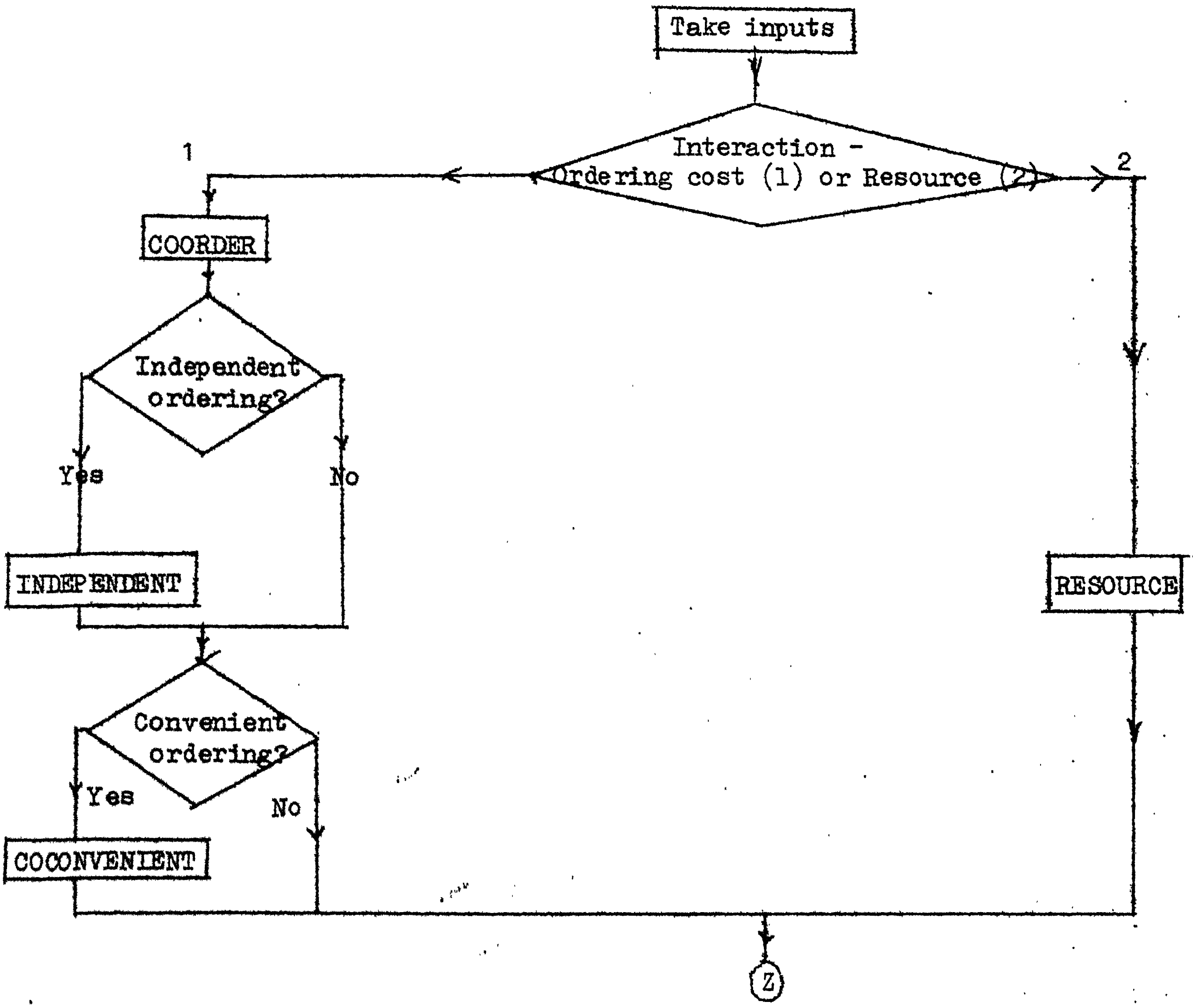

FIG. 4.3: COORDINATED SUBSYSTEM

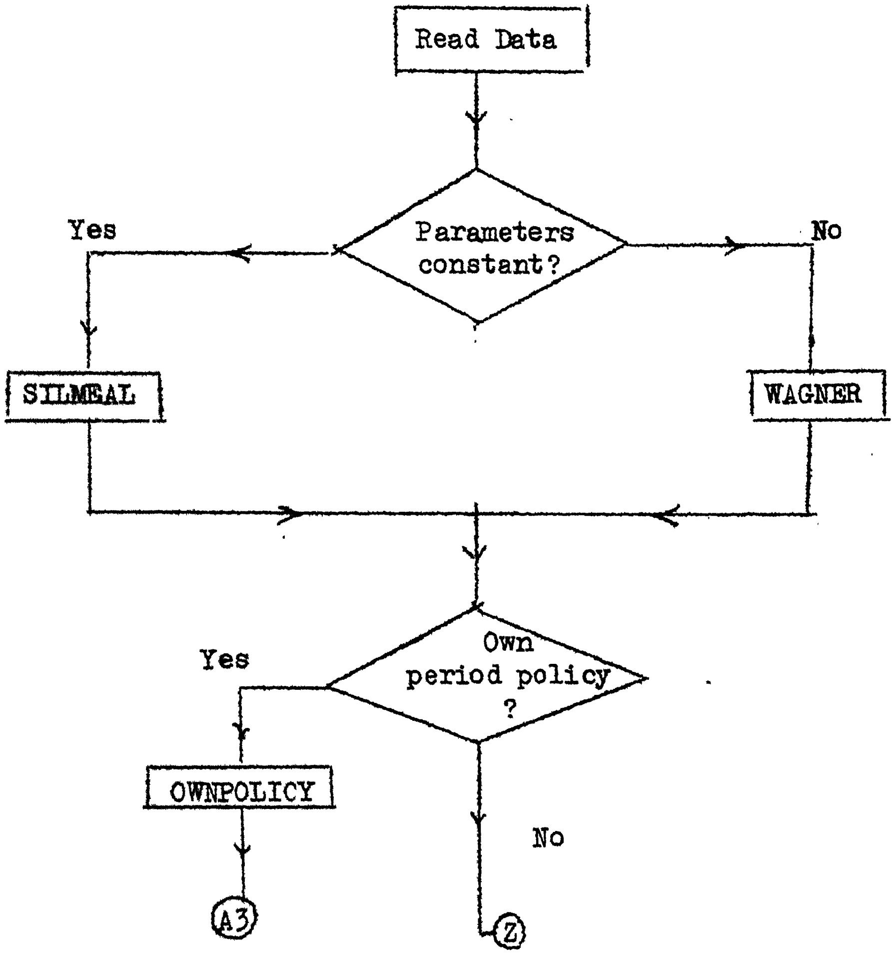

FIG. 4.4: DYNAMIC SUBSYSTEM.

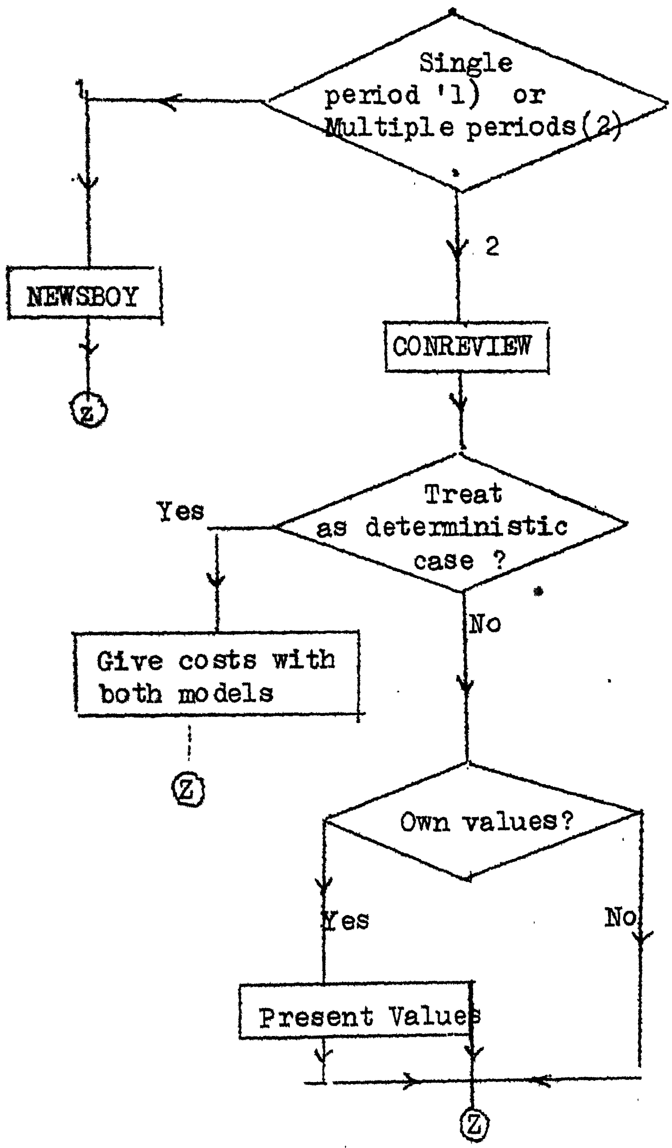

FIG. 4.5: STOCHASTIC SUBSYSTEM.

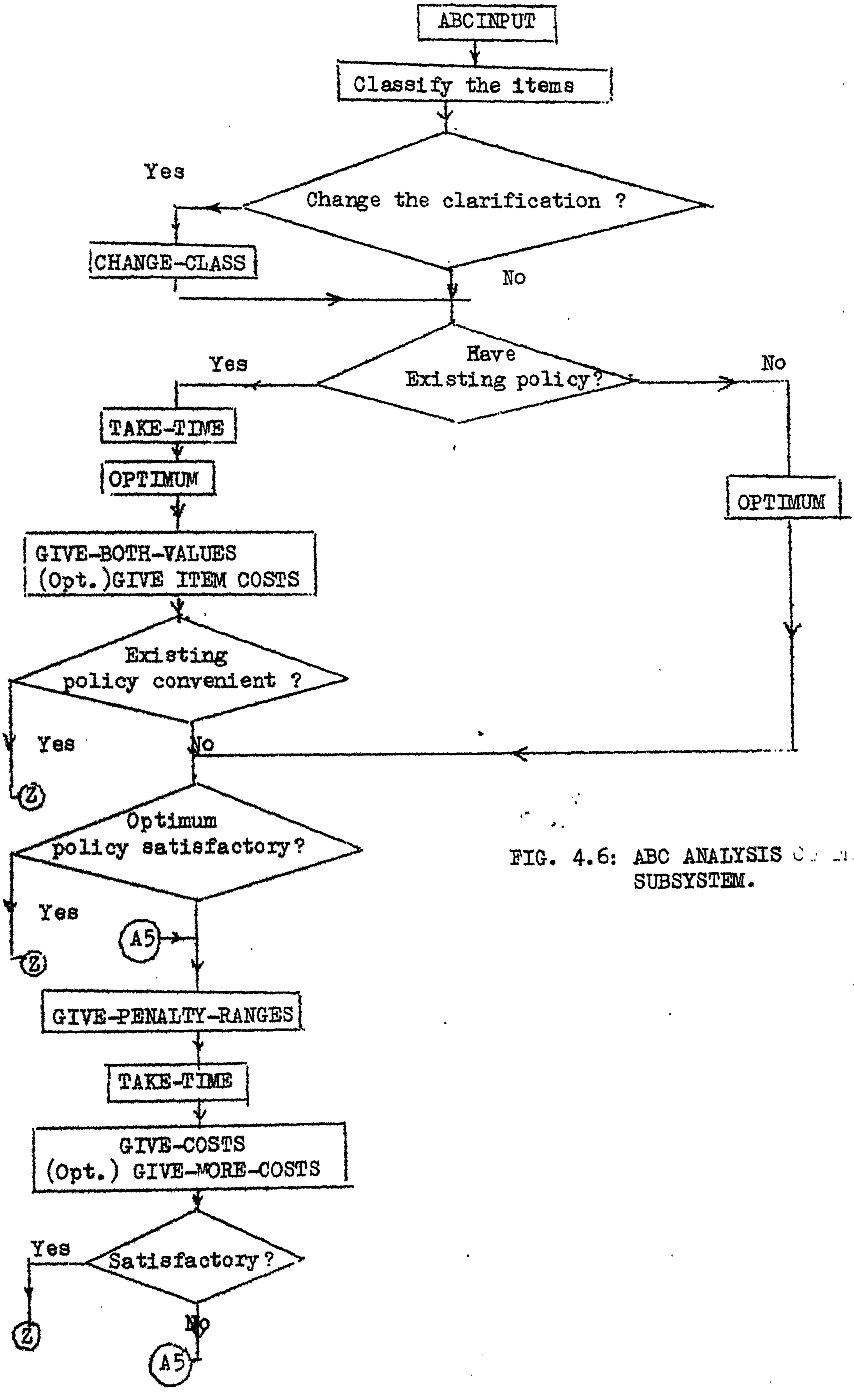

FIG. 4.6: ABC ANALYSIS [illegible]
SUBSYSTEM.

2) Discounttype:

This procedure finds out whether any discounts are to be allowed. If so, the nature of discount is found out.

3) Inputl :

This takes the inputs required from the user.

4) Corresponding:

The procedure calls appropriate procedures corresponding to the inputs given by the user. For example, if discounts are allowed for all units ordered, it calls proc-dure called ALLDISCOUNT.

5) Quantity:

It calculates the economic order quantity.

6) Totcost:

Given all the inputs like demand etc. it gives all performance measures like Holding costs, Ordering costs, TOtal cost, Shortage costs etc.

7) Alldiscount:

It provides the best order quantity and performance measures for the given price breaks in the case of all unit quantity discounts.

8) Incdiscount:

This procedure takes care of incremental quantity discounts.

9) Matcost:

This recursive function calculates material cost MC(Q) if Q units are ordered in the case of incremental quantity discounts.

10) Input2:

The user may like to change some parameters and see the effects. This procedure gives a menu interface of all the parameters, he would like to change. From this menu he selects the list of parameters to be changed. Then the system responds with the old values and accepts the new values. With these new values again the procedure CORRESPONDING is called.

11) Owntotcost:

In case, the user wants to try his own policy this procedure accepts the order quantity and provide him the cost details.

4.3.2 Dynamic

This subsystem considers the dynamic demand situations. The other procedures called in this subsystem are explained below.

1) Input1:

It takes the inputs required for the dynamic model.

2) Wagner:

This procedure determines the lot sizes to be procured in each period and corresponding costs using Wagner-Whitin algorithm.

3) Fcost:

This procedure gives minimum cost for each period which is used in next period dynamically. This is called by WAGNER.

$$F_k = \min_{0<j<k} [F_j + M_{jk}]$$

where,

F_k = Minimum cost program for periods 1,2,..., k

M_{jk} = Cost to be incurred in periods j+1 through k.

4) M:

This function determines the cost to be incurred in periods j+1 through k.

$$M_{jk} = A_{j+1} + C_{j+1} Q_{j+1} + \sum_{t=j+1}^{k-1} H_t \sum_{r=t-1}^{k} D_r$$

where,

A_j = ordering cost in j-th period

C_j = cost of item in j-th period

Q_j = Quantity to be ordered

H_j = Holding cost in j-th period

D_j = Demand in j-th period

This function is used in the procedure FCOST.

5) Silmeal:

When the cost parameters are constant the quantities to be ordered are determined using Silver-Meal Algorithm.

6) Ownpolicy:

This enables the user to compare the results if he follows his own period policy (Ex. 3 period policy, procuring once in 3 periods).

4.3.3 Stochastic:

This subsystem takes care of stochastic situations. The following procedures are invoked depending on the inventory situation.

1) Newsboy:

It takes care of single period model i.e., Newsboy-model. It makes use of a FORTRAN function called G01CEF (NAG Library) to find the standard normal deviate (z) for a specified value of distribution for $\phi(z)$.

k = G01CEF (CDF, IER)

CDF = Cumulative density function

k = Inverse normal

IER = Subroutine error.

2) Continuous Review (CONREVIEW):

This procedure considers continuous review situation and determines the Reorder-level and Order Quantity. It considers both the cases viz. Back order case and Lost

Sales case. It makes use of FORTRAN subroutines G01CEF (NAG) and MDNOR (IMSL). MDNOR is IMSL subroutine which gives the CDF value for the given value of k.

3) Deviate for Reorder level (DEVRO):

It determines k, CDF and probability density function and is called by CONREVIEW.

4) Prtotcost:

It gives the expected average cost depending upon the case i.e. Lost Sales or Back Ordered.

5) Comac:

The procedure gives the expected average cost given the reorder level and order quantity.

4.3.4 Coordinated:

This procedure deals with the coordination of multiple items and considers ordering cost interaction and Resource interaction.

1) Caltow:

It calculates the individual optimum ordering times for each item.

2) Coorder:

This procedure determines the optimum coordinated policies for the multiple items with the help of an iterative procedure. This procedure calls another procedure called COTOTCOST which gives all the costs required.

3) Give-All-Costs:

This procedure presents all the performance measures to the user.

4) Independent:

This procedure provides the user the results of ordering the multiple items independently.

5) Coconvenient:

This takes care of the situation where the user may like to co-ordinate the items at his convenience.

6) Resource:

This procedure helps the user in coordinating the items when there is constraint on resources.

4.3.5 ABC Analysis:

This subsystem classifies the items on the basis of Annual Usage Value. The data for all the items regarding code, demand, and other cost information are read from the data file called INPUT. Then, the system provides the facility for comparing the existing policy with optimum policy. In case both are not feasible the system guides the user to generate more alternatives to arrive at an economical one. The other procedure used in this subsystem are explained below.

1) ABCinput:

This procedure takes all the inputs required from the data file called INPUT.

2) Give-DV:

This procedure presents the user the annual usage value of each item.

3) Cutoff-Values:

This procedure requests the user for the cutoff values between A and B items and B and C items.

4) Class-output:

This presents the user the details of Annual usage value of each item and its class.

5) Change-Class:

This procedure provides the facility for changing the classification of items.

6) Existing:

This procedure with the help of some other procedures given below guides the user to a convenient policy if there is any existing policy.

7) Take-time:

It takes the ordering times for all the items from the user for a given policy.

8) Get-costs:

For the given policies of the items it determines all the performance measures.

9) Optimum:

This procedure determines the optimum policies and the

corresponding costs using coordination. This makes use of other procedures CALTOW, ABCSORT, COTOTCOST, and COORDER.

10) ABCsort:

It sorts the items according to their ordering times and their Annual usage value.

11) Common:

This procedure calls all the required procedures when there is existing policy or not.

12) Give-both-values:

This procedure gives the details of both existing and optimum coordinated policies to the user.

13) Give-item-costs:

This procedure presents the item costs at each ordering point. This will enable the decision maker to see whether any group quantity discounts are possible.

14) Range-output:

This procedure determines the penalties and the ranges of time between order allowed for that penalty. For example, for 10% increase in Total Cost of an item the maximum and minimum values of time between orders are calculated as follows:

TC = Total cost for optimum ordering policy

$TC' = 1.1\ (TC),$

$\text{Penalty} = (TC' - TC)$

t_j = $[2xTC' \pm \sqrt{(2xTC')^2 - 8xRxkxD}]/2xR$

R = Holding cost per time

K = Ordering cost

D = Demand

t = Time between order

TC for an item is calculated from the procedure GROUPTOTCOST. The penalty maximum and minimum values of Time between orders are determined by another procedure called Give-RANGES-PENALTY.

15) Give-fixed-order-costs:

In deciding the ordering times for all the items the selection of coordinated time is more essential. It is the one which decides the fixedordering costs. This procedure enable the user to have fixed ordering costs to a particular ordering time. In case he wants to increase the coordinate time from the previous policy he can find out the savings from fixed-ordering costs.

16) Give-Penalty-for-time:

This procedure gives the penalty if the user would like to follow the ordering time other than the optimum time. In order to decrease the ordering costs the user would like to coordinate all items. So naturally these times differ from the optimum times. With the help of this procedure he can know what is the Penalty he is going to incur by the decision.

17) Give-costs:

This procedure presents all the cost information like Holding costs, Ordering costs, Fixed Ordering costs and Total costs to the user.

18) Give-more-costs:

This procedure gives detailed information about the costs of each item which helps him for further thinking.

19) Starting:

This procedure is called if there is no existing policy. This also follow the same procedure as above with little change in providing information to the user.

CHAPTER V

CONCLUSIONS

In this tthesis a decision support system to support a manager in inventory policy decision making has been developed in line with the general frame work mentioned earlier. The system has been implemented on DEC-1090 Computer at IIT Kanpur.

The present system is designed to help the manager in various situations like static demand situation, dynamic, stochastic situations, coordinating multiple items and policy analysis. It is designed in modular form, so that future extensions or modifications are done easily. To enable interaction between the user and the system different kinds of interface like Q/A (Question/Answer) interface, and Menu interface etc. are incorporated in this system.

The DSS provides support to the decision maker rather than replacing him in making decisions. They are well suited for semi-structured problems, where a computer or a decision maker alone cannot make as good a decision as both in unison. Thus the computing power and long years of experience of a manager are combined to the best advantage in a DSS.

There has been a lot of research going on in this area of supporting decisions. The manager of future will be more involved in computers than today and hence the need for supporting him will be greater. So the DSS has come to stay as one of the distinct research areas as other respectable areas like MS/OR and MIS.

REFERENCES

1. Alter, Steven L: Decision Support Systems - Current Practices and Continuing Challenges, Addison Wesley Series, 1980.

2. Aggarwal, S.C., A Review of Current Inventory Theory and its Applications, International Journal of Production Research 12, 443-482 (1974).

3. Bedworth, David D. and Bailey, James, E.: Integrated Production Control Systems, John Wiley and Sons. Inc., 1982.

4. Bennett, John L.: Building Decision Support Systems, Addison- Wesley Series, 1983.

5. Blanning, R.W.: What is happening in DSS, Interfaces, Oct. 1983, pp. 71-80.

6. Bonczek, R.H., C.W. Holsapple and Whinston, A.B.: Foundations of Decision Support Systems, Academic Press, New York, 1981.

7. Buzacott, J.A.: Economic Order Quantities with Inflation, Operational Research Quarterly, 26, 553-558 (1975).

8. Davis, Gordon B. and Olson, M.H.; Management Information Systems, McGraw-Hill Series, 1984.

9. Eilon, S. and Lampkin, W., Inventory Control Abstracts (1953-65), Oliver and Boyd, Edinburgh and London, 1968.

10. Gingberg, M.J., Reitman, W.R. and Stohr, E.A.: Decision Support Systems, North-Holland, New York, 1982.

11. Goyal, S.K., Determination of Optimum Packaging Frequency of items Jointly Replenished, Management Science, 21, 436-443 (1974).

12. Herbert, Simon, A.: The Science of Management Decisions, Prentice-Hall Inc., 1977.

13. Herron, D.P.: Basic Inventory Program (BIP) for Six item Group on Tl-59 Calculator, Stanford Research Institute, Menlo Park, California, 1978.

14. Hurrion, R.D., An Investigation of Visual Interactive Simulation Methods Using the Job-Shop Scheduling Problem, Journal of the Operational Research Society, 29, 1085-1093 (1978).

15. Keen, Peter, G.W., Scott Mortan, Michael S.: Decision Support Systems, An Organizational Perspective, Addison-Wesley Series, 1978.

16. Krupp, J., Programmable Calculators: The New Materials Management Tool, Production and Inventory Management, 18, 88-103 (1977).

17. Little, J.D.C.: Models and Managers - The Concept of a Decision Calculus, Management Science 16, 466-485 (1970).

18. Love, Stephen, F.: Inventory Control, McGraw Hill Series, 1979.

19. McChosh, Andrew M. and Scott Mortan, Michael S., Management Decision Support Systems, The Macmillan Press Ltd., 1978.

20. Montgomery, D.C. and Johnson, L.A., Operations Research, Production Plannihg, Scheduling and Inventory Control, John Wiley and Sons, 1974.

21. Naddor. E: Inventory Systems, John Wiley and Sons, New York, N.Y., 1966, 96-102.

22. Nahimas, S.: Myopic Approximations for the Perishable Inventory Management, Management Science 22, 1002-1008 (1976).

23. Peterson Rein, Silver Edward A: Decision Systems for Inventory Management and Production Planning. The Wiley Series, 1979.

24. Plassal, George W. and Welch, Evert W.: The Role of Top Management in the Control of Inventory, Prentice-Hall, 1979.

25. Schwarz. L., and Schrage. L.: Optimal and System Myopic Policies for Multi-Echelon Production/Inventory Assembly Systems, Management Science 21, 1285-1294 1974.

26. Silver, Edward A.: Inventory Management: A Review and Critique, Working Paper, 1979.

27. Silver, E.A., and Hical, H.C., A Heuristic for Selecting Lot Size Requirements for the case of a Deterministic Time Varying Demand Rate and Discrete Opportunities for Replenishment, Production and Inventory Management, Vol. 14, No. 2, 1973, p. 64-74.

28. Silver, E.A.: A Simple Method of Determining Order Quantities in Joint Replenishments under Deterministic Demand, Management Science 22, 1351-1361 (1976).

29. Silver, E.A.: The Use of Programmable Calculators in Inventory Management, Working Paper No. 129, Department of Management Sciences, Univ. of Waterloo, Waterloo, Ontario, 1979.

30. Simon, H.A., The New Science of Management Decision, New York: Harper and Row, 1960.

31. Thierauf, Robert J.: Decision Support System for Effective Planning and Control: A Case Study Approach, Prentice Hall Inc. 1982.

32. Wagner, H.M., and Whitin, T.M.,: Dynamic Version of Economic Lot Size Model, Management Science 3, 89-96 (1958).

33. Watson, H.J. and Hill, M.M.: DSS or What Didnot Happen with MIS, Interfaces, Oct. 1983, pp. 81-88.

EXAMPLE SESSION

```
.EX FINAL4.PAS,SYS:FTNLNK.REL,PUB:NAG.REL/SEA,/SEA SYS:IMSL
LINK:   Loading
[LNKXCT FINAL4 execution]

*

   THIS SYSTEM SUPPORTS YOU TO ARRIVE AT CONVENIENT
   POLICIES FOR INVENTORY PROBLEMS. GIVEN THE DATA IT PROVIDES
   OPTIMUM POLICIES AND THEN IT GUIDES YOU TO ARRAIVE AT THE
   CONVENIENT VALUES IF OPTIMUM ONES ARE NOT FEASIBLE.
--------------------------------------------------------------
          SAMPLE PROBLEM A.(SIMPLE EOQ WITH EXTENSIONS)
          -------------------------------------------
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):1
DOES THE DEMAND VARY EVERY MONTH FOR THIS ITEM(Y/N):N
IS THE REPLENISHMENT INSTANTANEOUS(Y/N):N
DO YOU ALLOW SHORTAGES(Y/N):Y
DOES THE UNIT COST DECREASE IF YOU PURCHASE MORE NO OF ITEMS(Y/N):N

NOW PLEASE ENTER THE DATA
DEMAND:25.0
ORDERING COST:10.0
FIXED HOLDING COST PER TIME:1.0
HOLDING COST PER RUPEE PER TIME:0.01
RATE OF REPLENISHMENT:30.0
SHORTAGE COST PER UNIT INDEPENDENT OF TIME:2.0
SHORTAGE COST PER UNIT PER TIME:1.25
UNIT COST OF ITEM:0.25


ORDER    32.38UNITS  EVERY     1.29 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST=    7.72
HOLDING COST=     1.23
SHORTAGE COST=    3.05
COSTOFITEM=       6.25

    TOTALCOST=      18.25
DO YOU WISH TO CHANGE SOME PARAMETERS AND TRY(Y/N)?:
Y
                 SENSITIVITY ANALYSIS
                 -------------------
WHICH OF THE FOLLOWING PARAMETERS YOU WOULD LIKE TO CHANGE

           1.ORDERING COST
           2.DEMAND
           3.HOLDING COST
           4.UNIT COST OF ITEM
           5.RATE OF REPLENISHMENT
```

```
          6.SHORTAGE COSTS
   SELECT THE OPTION (IF YOU HAVE MORE THAN ONE CHANGE
MENTION THEM SEPARATED BY BLANKS):1 4
OLD ORDERING COST =    10.00
ENTER NEW ORDERING COST:11.0
OLD UNIT COST=     0.25
ENTER NEW UNIT COST:0.26


ORDER     34.85UNITS  EVERY     1.39 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST=     7.88
HOLDING COST=      1.24
SHORTAGE COST=     3.32
COSTOFITEM=        6.49

    TOTALCOST=       18.95
WANT TO TRY WITH SOME OTHER CHANGES IN PARAMETERS(Y/N):N
DO YOU WANT TO USE YOUR OWN POLICY AND TRY(Y/N):Y
          USER SPECIFIED POLICY
          --------------------
PLEASE ENTER YOUR ORDER QUANTITY:35.0


ORDER     35.00UNITS  EVERY     1.40 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST=     7.14
HOLDING COST=      1.43
SHORTAGE COST=     2.82
COSTOFITEM=        6.25

    TOTALCOST=       17.65
DO YOU LIKE TO TRY WITH OTHER VALUES AGAIN(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:C
          SAMPLE PROBLEM B.(QUANTITY DISCOUNTS)
          -------------------------------------
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):1
DOES THE DEMAND VARY EVERY MONTH FOR THIS ITEM(Y/N):N
IS THE REPLENISHMENT INSTANTANEOUS(Y/N):Y
DO YOU ALLOW SHORTAGES(Y/N):N
DOES THE UNIT COST DECREASE IF YOU PURCHASE MORE NO OF ITEMS(Y/N):Y
IS THE DECREASE ALLOWED FOR ALL ITEMS(1) OR FOR ADDITIONALITEMS(2):1

NOW PLEASE ENTER THE DATA
DEMAND:300000.0
ORDERING COST:100.0
FIXED HOLDING COST PER TIME:1.2
HOLDING COST PER RUPEE PER TIME:0.2
WHAT IS THE NO OF PRICE BREAKS:4
```

```
TYPE THE PRICE BREAKS AND CORRESPONDING UNIT PRICES
             IN THE FOLLOWING MANNER
LOWER UPPER UNIT
RANGE RANGE PRICE
0.0 9999.0 1.0
9999.0 29999.0 0.98
29999.0 49999.0 0.96
49999.0 99999.0 0.94


ORDER  9998.99UNITS  EVERY    0.03 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST= 3000.30
HOLDING COST=  6979.30
SHORTAGE COST=   -0.00
COSTOFITEM=    2.93E+05

    TOTALCOST=  303979.60
DO YOU WISH TO CHANGE SOME PARAMETERS AND TRY(Y/N)?:
N
DO YOU WANT TO USE YOUR OWN POLICY AND TRY(Y/N):Y
          USER SPECIFIED POLICY
          --------------------
PLEASE ENTER YOUR ORDER QUANTITY:6550.0


ORDER  6550.00UNITS  EVERY    0.02 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST= 4580.15
HOLDING COST=  4585.00
SHORTAGE COST=   -0.00
COSTOFITEM=    3.00E+05

    TOTALCOST=  309165.15
DO YOU LIKE TO TRY WITH OTHER VALUES AGAIN(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:C
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):1
DOES THE DEMAND VARY EVERY MONTH FOR THIS ITEM(Y/N):N
IS THE REPLENISHMENT INSTANTANEOUS(Y/N):Y
DO YOU ALLOW SHORTAGES(Y/N):N
DOES THE UNIT COST DECREASE IF YOU PURCHASE MORE NO OF ITEMS(Y/N):Y
IS THE DECREASE ALLOWED FOR ALL ITEMS(1) OR FOR ADDITIONALITEMS(2):2

NOW PLEASE ENTER THE DATA
DEMAND:9.0
ORDERING COST:4.0
FIXED HOLDING COST PER TIME:0.5
HOLDING COST PER RUPEE PER TIME:0.01
WHAT IS THE NO OF PRICE BREAKS:3
```

```
TYPE THE PRICE BREAKS AND CORRESPONDING UNIT PRICES
              IN THE FOLLOWING MANNER
LOWER UPPER UNIT
RANGE RANGE PRICE
1.0 10.0 10.0
11.0 30.0 9.5
31.0 999.0 9.0


ORDER    16.50UNITS  EVERY     1.83 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST=    4.90
HOLDING COST=     4.90
SHORTAGE COST=   -0.00
COSTOFITEM=      85.49

    TOTALCOST=       95.31
DO YOU WISH TO CHANGE SOME PARAMETERS AND TRY(Y/N)?:
N
DO YOU WANT TO USE YOUR OWN POLICY AND TRY(Y/N):Y
PLEASE ENTER YOUR ORDER QUANTITY:20.0


ORDER    20.00UNITS  EVERY     2.22 PERIODS

WITH THIS POLICY THE COST DETAILS ARE
-------------------------------------

ORDERING COST=    4.05
HOLDING COST=     5.94
SHORTAGE COST=   -0.00
COSTOFITEM=      85.49

    TOTALCOST=       95.49
DO YOU LIKE TO TRY WITH OTHER VALUES AGAIN(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:C
          SAMPLE PROBLEM C.(DISCRETE LOT SIZING)
          -------------------------------------
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):1
DOES THE DEMAND VARY EVERY MONTH FOR THIS ITEM(Y/N):Y
IS THE DEMAND PREDICTABLE(Y/N):Y
ARE THE PARAMETERS (EX. HOLDING COSTS) CONSTANT FOR ALL PERIODS(Y/N):N

FOR HOW MANY PERIODS:6
ENTER THE DEMANDS FOR  6 PERIODS SEPARATED BY BLANKS
DEMANDS:60.0 100.0 140.0 200.0 120.0 80.0
ENTER THE ORDER COSTS FOR  6 PERIODS SEPARATED BY BLANKS
ORDER COSTS:150.0 140.0 160.0 160.0 170.0 190.0
ENTER THEHOLDING COSTS FOR  6 PERIODS SEPARATED BY BLANKS
HOLDING COSTS:1.0 1.0 2.0 2.0 2.0 2.0
ENTER THEUNIT COSTS FOR  6 PERIODS SEPARATED BY BLANKS
UNIT COSTS:7.0 7.0 8.0 7.0 6.0 10.0
```

```
AMOUNTS TO BE ORDERED IN EACH PERIOD

                              PERIOD

           1          2           3          4          5            6
QTY       60.00     240.00       0.00     200.00     200.00        0.00

TOTALCOST= 5620.000
DO YOU WANT TO USE YOUR OWN POLICY AND TRY:Y
          USER SPECIFIED POLICY
          --------------------
ONCE IN HOW MANY PERIODS DO YOU ORDER:2
TOTALCOST= 10499.999
TYPE S TO STOP OR C TO CONTINUE:C
          SAMPLE PROBLEM D.(STOCHASTIC DEMANDS)
          -------------------------------------
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):1
DOES THE DEMAND VARY EVERY MONTH FOR THIS ITEM(Y/N):Y
IS THE DEMAND PREDICTABLE(Y/N):N
IS THIS FOR SINGLE PERIOD(1) OR MULTIPLE PERIODS(2):2
ENTER THE MEAN DEMAND:1000.0
ENTER THE STANDARD DEVIATION:250.0
SPECIFY THE CASE,BACK ORDERED(1) OR LOST SALES(2):1
ENTER EXPECTED DEMAND:10000.0
ORDERING COST:100.0
HOLDING COST PER UNIT TIME:0.15
BACK ORDER COST:1.0
REORDER LEVEL =          1396
ORDER QUANTITY =         3760
EXPECTED TOTAL COST = 623.388
DO YOU WANT TO TRY DETERMINISTIC MODEL WITH TH SAME VALUES:Y
          TRY AS A DETERMINISTIC MODEL
          ---------------------------
ENTER ASSUMED REORDER LEVEL:1000.0
           STOCHASTIC      DETERMINISTIC
           CASE            CASE
QTY=            3760      3651
R O LEVEL=      1396      1000
EAC=         623.388   820.840
DO YOU WANT TO USE YOUR OWN VALUES AND TRY(Y/N):Y
ENTER YOUR ORDER QUANTITY:3760.0
ENTER YOUR REORDER LEVEL:1400.0
           OPTIMUM         YOUR
           VALUES          VALUES
QTY             3760      3760
R O LEVEL       1396      1400
EAC          623.388   623.396
DO YOU WANT TRY WITH OTEHR VALUES AGAIN(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:C
          SAMPLE PROBLEM E.(CO-ORDINATION)
          --------------------------------
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):2
DO YOU LIKE TO CLASSIFY THE ITEMS ACCORDING TO ANNUAL USAGE(Y/N):N
FOR HOW MANY ITEMS:3
WHAT IS THE COMMON BASIS ORDERING COST(1) OR RESOURCES(2):2
```

```
ENTER BOUND ON RESOURCE:10600.0
ENTER RESOURSES NEEDED FOR 3 ITEMS SEPARATED BY BLANKS
:40.0 30.0 35.0
ENTER DEMANDS FOR  3 ITEMS SEPARATED BY BLANKS
:800.0 900.0 1000.0
ENTER HOLDING COSTS FOR  3 ITEMS SEPARATED BY BLANKS
:8.0 6.0 7.0
ENTER ORDERING COSTS FOR  3 ITEMS SEPARATED BY BLANKS
:64.0 64.0 64.0
EOQ[ 1] =  89.442
EOQ[ 2] = 109.544
EOQ[ 3] = 106.904
TYPE S TO STOP OR C TO CONTINUE:C
DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):2
DO YOU LIKE TO CLASSIFY THE ITEMS ACCORDING TO ANNUAL USAGE(Y/N):N
FOR HOW MANY ITEMS:15
WHAT IS THE COMMON BASIS ORDERING COST(1) OR RESOURCES(2):1
ENTER JOINT ORDERING COST:43.5
ENTER DEMANDS FOR 15 ITEMS SEPARATED BY BLANKS
:10000.0 35000.0 8000.0 9000.0 50000.0 15000.0 20000.0 12500.0 10000.0
4250.0 2500.0 10000.0 4000.0 2000.0 1500.0
ENTER HOLDING COSTS FOR 15 ITEMS SEPARATED BY BLANKS
:10.0 2.0 8.0 5.0 1.0 2.0 2.0 1.6 1.45 2.0 3.0 1.0 1.25 3.0 2.0
ENTER ORDERING COSTS FOR 15 ITEMS SEPARATED BY BLANKS
:10.0 8.0 8.0 6.0 8.0 5.0 7.0 4.5 8.0 5.0 7.0 10.0 5.0 6.0 9.0
FOR ORDER COST INTERACTION
COORDINATED TIME=         0.02
OREDRING COSTS=        3696.10
HOLDING COSTS=         5724.87
FIXED ORDERING COSTS= 2028.77
TOTALCOST=            11449.75
WANT TO TRY ORDERING INDEPENDENTLY AND FIND THE TOTALCOSTS(Y/N)?:Y
          TRY INDEPENDENT ORDERING
          ----------------------

TOTAL COST WHEN ORDERED INDEPENDENTLY = 24068.498
WOULD YOU LIKE TO COORDINATE AT YOUR CONVINIENCE(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:C
  SAMPLE PROBLEM F.(POLICY ANALYSIS FOR SELECTIVE CONTROL ITEMS)
  -------------------------------------------------------------

DO YOU LIKE TO REVIEW SINGLE ITEM(TYPE 1) OR MULTIPLE ITEMS(TYPE 2):2
DO YOU LIKE TO CLASSIFY THE ITEMS ACCORDING TO ANNUAL USAGE(Y/N):Y
PLEASE ENTER THE NO OF ITEMS:6
ENTER THE FIXED ORDERING COST:3.0
FIXED HOLDING COST:1.0
VARIABLE HOLDING COST(ie.% OF UNIT COST):0.5
ANNUAL USAGE VALUES IF ALL THE ITEMS ARE THE FOLLOWING
 ITEM       ITEM    USAGE
 NO         CODE    VALUE
 1         AD13     10000.000
 2         AC13      2400.000
 3         AB12      2000.000
 4         KHE6       190.000
 5         JH56        15.000
 6         EF13         8.000
```

CLASSIFICATION

PLEASE ENTER THE CUT OFF VALUES
between A and B items:5000.0
between B and C items:200.0
THE FOLLOWING IS THE CLASSIFICATION OF ITEMS

ITEM NO	ITEM CODE	DEMAND	UNIT COST	USAGE VALUE	CLASS
1	AD13	1000.000	10.000	10000.000	A
2	AC13	120.000	20.000	2400.000	B
3	AB12	100.000	20.000	2000.000	B
4	KHE6	19.000	10.000	190.000	C
5	JH56	3.000	5.000	15.000	C
6	EF13	4.000	2.000	8.000	C

WANT TO MAKE CHANGES IN THE CLASSIFICATION(Y/N):
Y
PLEASE MENTION THE CHANGES

ITEM NO	CHANGE FROM	CHANGE TO	TYPE S TO STOP M TO MORE
4	C	B	S

THE FOLLOWING IS THE CLASSIFICATION OF ITEMS

ITEM NO	ITEM CODE	DEMAND	UNIT COST	USAGE VALUE	CLASS
1	AD13	1000.000	10.000	10000.000	A
2	AC13	120.000	20.000	2400.000	B
3	AB12	100.000	20.000	2000.000	B
4	KHE6	19.000	10.000	190.000	B
5	JH56	3.000	5.000	15.000	C
6	EF13	4.000	2.000	8.000	C

DO YOU HAVE ANY EXISTING POLICY(Y/N):
Y
ENTER THE EXISTING ORDERING TIMES OF ALL ITEMS

ORDERING TIME (IN MONTHS)	ITEM NOS SEPARATED BY BLANKS
*NOTE*START WITH THE ITEMS WITH SMALLEST ORDERING TIME	
3.0	1 2 3 4
TYPE O TO OVER OR S TO SOME MORE:S	
12.0	5 6
TYPE O TO OVER OR S TO SOME MORE:O	

INFORMATION ABOUT ORDERING TIMES OF EXISTING AND OPTIMUM POLICIES

NO	CODE	EXISTING (in months)	OPTIMUM (in months)
1	AD13	3.00	1.03
2	AC13	3.00	3.09
3	AB12	3.00	5.15
4	KHE6	3.00	6.18
5	EF13	12.00	8.24
6	JH56	12.00	13.39

COST INFORMATION

	EXISTING	OPTIMUM
COORDINATED TIME	3.00	1.03
HOLDING COSTS	167.55	94.20
VAR ORDERING COSTS	75.00	59.36

FIXED ORDER COSTS	12.00	34.83
TOTALCOST	254.55	188.41

DO YOU WANT TO HAVE LOOK AT THE ITEM COST DETAILS(Y/N):Y

FOR EXISTING POLICY

ORDERING-TIME (in months)	ITEM-COSTS (in RS)
3.00	3647.49
12.00	25.99

FOR OPTIMUM COORDINATED POLICY

ORDERING-TIME (in months)	ITEM-COSTS (in RS)
1.03	858.33
3.09	618.00
5.15	858.33
6.18	97.84
8.24	5.49
13.39	16.73

DO YOU WANT TO CONTINUE WITH EXISTING POLICY(Y/N):N

IS THE OPTIMUM POLICY CONVINIENT(Y/N):N

THE FOLLOWING DETAILS WILL GIVE YOU THE PENALTIES IF YOU FOLLOW OTHER THAN INDIV. OPTIMUM ORDERING TIMES. THIS MAY HELP YOU IN SELECTING CONVINIENT ORDERING TIMES.

ITEM NO	ITEM CODE	CLASS	PRESENT ORDER TIME	IND OPT. ORDER TIME	RANGES OF ORDER TIMES AND PENALTIES: FOR 10% INCREASE IN COSTS			FOR 20% INCREASE IN COSTS		
					MAX	MIN	PENALTY	MAX	MIN	PENALTY
1	AD13	A	3.00	0.52	0.81	0.33	4.58	0.97	0.28	9.16
2	AC13	B	3.00	2.94	4.60	1.89	3.24	5.50	1.58	6.49
3	AB12	B	3.00	5.12	7.97	3.28	4.69	9.53	2.74	9.38
4	KHE6	B	3.00	6.57	10.25	4.22	1.09	12.26	3.53	2.18
5	EF13	C	12.00	8.44	13.15	5.41	0.28	15.73	4.53	0.56
6	JH56	C	12.00	13.69	21.32	8.78	0.35	25.50	7.34	0.70

OPT.COORDINATED TIME= 1.03 OPT TOTALCOST = 188.41

WANT TO HAVE FIXED ORDERING COSTS FOR YOUR CHOICE OF TIME(Y/N)?:Y

ENTER THE YOUR COORDINATED-TIME:2.0

IF 2.00 IS COORDINATED TIME

NO OF ORDERS TO BE PLACED= 6.00

FIXED ORDERING COSTS = 17.99

WANT FIXED ORDER COSTS FOR ANY OTHER VALUE OF TIME(Y/N):Y

ENTER THE YOUR COORDINATED-TIME:0.48

IF 0.48 IS COORDINATED TIME

```
NO OF ORDERS TO BE PLACED=   25.00
FIXED ORDERING COSTS =       75.00
WANT FIXED ORDER COSTS FOR ANY OTHER VALUE OF TIME(Y/N):N
 DO YOU LIKE TO FIND PENALTY FOR A PARTICULAR ORDERING TIME(Y/N):Y
ENTER THE ITEM NO:1
ENTER THE TIME BETWEEN ORDER:2.0
IF YOU USE  2.000PENALTY IS  47.67 RS
WANT FOR ANY OTHER ITEM(Y/N):N
 *NOW  ENTER YOUR CHOSEN ORDERING TIMES IN THE FOLLOWING MANNER*
ORDERING TIME      ITEM NOS SEPARATED BY BLANKS
  (IN MONTHS)
-------------    ------------------------------------------------------
       *NOTE*START WITH THE ITEMS WITH SMALLEST ORDERING TIME
2.0             1
TYPE O TO OVER OR S TO SOME MORE:S
4.0             2 3 4
TYPE O TO OVER OR S TO SOME MORE:S
12.0            5 6
TYPE O TO OVER OR S TO SOME MORE:O

       COST-INFORMATION

COORDINATED TIME=          2.00 MONTHS
HOLDING COSTS =          134.71 RS
VAR ORDERING COSTS=       60.00 RS
FIXED ORDERING COSTS=     17.99 RS
TOTALCOST=               212.71 RS
WANT MORE_DETAILS ABOUT HOLDING & ORDERING COSTS(Y/N):Y
     THE FOLLOWING INFORMATION GIVES YOU THE HOLDING & ORDERING
     COSTS WITH YOUR ORDERING POLICY AND THIER INDIVIDUAL OPTI-
MUM ORDERING TIMES
              YOUR VALUES            INDIV OPT. VALUES
              ------------          ------------------

NO  CODE  ORDERING    HOLD    ORDER    ORDERING    HOLD   ORDER
            TIME      COSTS   COSTS      TIME      COSTS  COSTS
         (in months)                 (in montths)

----------------------------------------------------------------------

 1  AD13     2.00  87.50   6.00          0.52  22.75  23.07
 2  AC13     4.00  21.99  12.00          2.94  16.22  16.27
 3  AB12     4.00  18.33  30.00          5.12  23.46  23.43
 4  KHE6     4.00   3.32   9.00          6.57   5.46   5.47
 5  EF13    12.00   2.02   1.00          8.44   1.42   1.42
 6  JH56    12.00   1.53   2.00         13.69   1.75   1.75

                      -------- --------
          TOTAL   =   134.71    60.00
WANT TO TRY WITH OTHER POLICY(Y/N):Y
WANT DETAILS OF RANGES AND PENALTIES(Y/N):N
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 *NOW  ENTER YOUR CHOSEN ORDERING TIMES IN THE FOLLOWING MANNER*
ORDERING TIME      ITEM NOS SEPARATED BY BLANKS
  (IN MONTHS)
--------------    -------------------------------------------------
       *NOTE*START WITH THE ITEMS WITH SMALLEST ORDERING TIME
1.0              1
TYPE O TO OVER OR S TO SOME MORE:O

       COST-INFORMATION

COORDINATED TIME=         1.00 MONTHS
HOLDING COSTS =          90.96 RS
VAR ORDERING COSTS=      66.00 RS
FIXED ORDERING COSTS=    35.99 RS
TOTALCOST=              192.96 RS
WANT MORE_DETAILS ABOUT HOLDING & ORDERING COSTS(Y/N):N
WANT TO TRY WITH OTHER POLICY(Y/N):N
TYPE S TO STOP OR C TO CONTINUE:S

EXIT
```